ECOLOGICAL AND COMMUNITY RELATIONSHIPS OF *ERIOGONUM CORYMBOSUM* (POLYGONACEAE) IN THE UINTA BASIN, UTAH

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Abstract.— Ecological and community relationships of 10 different plant communities in the Uinta Basin, Utah, where *Eriogonum corymbosum* was found to grow were studied and described. Each community was sampled to determine the amount of ground cover, percent composition, frequency, and density of participating species. Physical site factors, viz., soil texture, total soluble salts, pH, cation exchange capacity, and amounts of calcium, magnesium, potassium, and sodium were determined. The 10 communities were compared to determine the degree of similarity between them. Correlations between individual plant species and measurable characteristics of the community were attempted. Evidence is presented that the distributional patterns of some species are related to these measured characteristics. *Eriogonum corymbosum, Chenopodium leptophyllum, Atriplex confertifolia, Stipa comata, Artemisia tridentata,* and *Agropyron smithii* showed correlation to both vegetational and edaphic factors of the community.

Total vegetative cover increased from desert to mountain in the Uinta Basin. As the vegetative cover increased, soil depth also increased. *Eriogonum corymbosum* decreased in importance in the higher elevation communities.

Eriogonum corymbosum was studied taxonomically, which demonstrated the presence of a previously undescribed variety. It is suggested that *E. corymbosum* var. *corymbosum,* found generally in the desert areas of the basin, is composed of a series of ecotypes that inhabit shallow soils and prefer communities that show high degrees of disturbance, little competition, fairly high levels of soluble salts in the soil, and are found at elevations below 5500 feet. *Eriogonum corymbosum* var. *erectum,* on the other hand, does best in communities above 6000 feet that show less disturbance than the desert areas, have deeper soils, and low levels of soluble salts.

Eriogonum corymbosum Benth. in DC (wild buckwheat) is a low-growing, perennial shrub that occurs in much of the cold temperate desert shrub regions of Colorado, Utah, and Nevada. In the Uinta Basin its growth is widespread on several different geological formations. In some areas its distribution is restricted to a specific formation, while elsewhere its distribution appears unrestricted.

The ecology of *E. corymbosum* is not well known, and available literature on the subject is fragmentary and scattered. Welsh (1957), in a study of the Dinosaur National Monument in the Uinta Basin, Utah, describes its occurrence on the Moenkopi and Mowry shale formations. He states that it appears to be restricted to these formations and grows only where the formations are fully exposed. It is the dominant plant of much of the Mowry Shale formation.

In an ecological study of the Flaming Gorge Reservoir Basin, Flowers (1957) lists *E. corymbosum* as a member of a zone of vegetation forming a junction between the river banks and the uplands, where it appears frequently on dry hillsides at about 1700 m (5600 feet). Graham (1937) found it growing with sagebrush on Red Creek.

Many writers have noted that plants are indicators of certain soils and geological formations. Graham (1937) wrote of the existence of endemics on the Green River shale formation in the Uinta Basin. Cannon (1952) noted the correlation between uranium-vanadium deposits and vegetation. Mason (1946) states that some soils, such as the serpentine soils, are well known for the endemic species that occur on them. Krucheberg (1951, 1954), Whittaker (1954), and Waler (1954) note a correlation between endemics and indicator species of the serpentine soils of California.

Kearney et al. (1914) in Tooele Valley, Utah, found that different types of native vegetation indicated conditions of moisture and salinity of the soil on which they were

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found. Shantz and Piemeisel (1940) found conditions in Escalante Valley, Utah, similar to those found in Tooele Valley, Utah, by Kearney et al. (1914). Fautin (1946) noted shadscale scattered in the more xeric and higher saline areas of valleys in central Utah. Billings (1949, 1950, 1951, 1952) states that chemical differences in soils may produce marked differences in the vegetation within fairly uniform climatic areas, that vegetation zones can be correlated with climatic and soils factors, and that the mosaic of smaller vegetational differences within a large zone may be caused by edaphic factors. He also noted *Atriplex confertifolia* to be an indicator of subsoil salinity. Gates et al. (1956) considered the edaphic factors, soluble salts, saturated extract conductivity, and exchangable sodium, to be of primary importance in determining the distribution of some shrub types. Thatcher (1959) and Robertson et al. (1966) found that *Artemisia tridentata* occurred only on moderately deep to deep, loamy soils.

Little has been published on the subject of indicator species concerned with the cold temperate desert shrub regions of the west. A knowledge of indicator species such as *E. corymbosum* is desirable because this species grows on peculiar soil types (i.e., soils of high or low pH, high or low salt content, etc.) and thus becomes important to the ecologist attempting to delineate or describe areas of the cold temperate regions.

During this study, I recognized from an ecological standpoint two distinct varieties. Consequently, the two varieties were named *E. corymbosum* Benth. in DC var. *corymbosum* and *E. corymbosum* Benth. in DC var. *erectum* Reveal and Brotherson (Reveal 1967).

Eriogonum corymbosum var. *corymbosum* has its distribution centered mainly in northeastern and central Utah, but it extends into northwestern Colorado and extreme southwestern Wyoming. It also extends southward to northcentral and northwestern Arizona.

Eriogonum corymbosum var. *erectum* is widely scattered in northeastern Utah, extending from western Wasatch County to extreme western Uintah County, mainly above 1800 m (6000 feet) elevation.

STUDY AREA

The Uinta Basin is a broad, elongated, asymmetric basin lying in the northeastern corner of Utah and extending into northwestern Colorado. It is both a structural and a topographic basin and is a subdivision of the Colorado Plateau province (Marsell 1964). It encompasses some 12,000 square miles and is about 150 miles (240 km) long in an east-west direction and 100 miles (160 km) wide in a north-south direction (Dastrup 1963).

The basin's northern boundary (Fig. 1) is in the Uinta Mountains, which reach elevations of 4100 m (13,500 feet). On the south it is bounded by the rim of the Tavaputs Plateau, which appears to rise roughly but steadily to a dip slope. Its west rim is flanked by the eastern slopes of the Wasatch Mountains, but its eastern side is not so sharply defined topographically (Marsell 1964).

Much of the central portion of the Uinta Basin is desert with an annual precipitation of less than 24 cm (10 inches). The gently sloping floor lies between 1500 m (5000 feet) and 1800 m (6000 feet) in elevation, but it reaches as much as 2100 m (7000 feet) at the foot of the Uinta Mountains.

The basin is drained in a somewhat centripetal pattern by three major streams and their tributaries (Fig. 1). The Duchesne River flows in a southeast direction and the White River flows westward. These two streams, along with their tributaries, drain the entire basin excepting the northeast corner. This corner is drained by the third major stream, the Green River, which crosses the East Tavaputs Plateau to meet the Colorado. The Duchesne and its tributaries (Rock Creek, Yellowstone River, Lake Fork, and the Uinta River) drain almost the entire Utah part of the basin, and the White River drains the Colorado portion. The Strawberry River, found in the western end, is the only stream of any size that drains the southern part of the basin (Marsell 1964, Dastrup 1963).

The land surface of the basin is rough and broken, cut in many places by deep gorges. Bare rock surfaces are widely scattered, forming cliffs, deep slopes, and stripped surfaces in many places. The soil is highly variable, ranging from deep, heavy clays to shallow, sandy soils. In much of the basin a calcareous layer can be found (Marsell 1964).

GEOLOGY

The Uinta Basin is a typical Rocky Mountain-type assymetric Tertiary basin. It was formed by the gradual settling of the interior area below the surface of deposition and concurrent lesser sinking or upward movement of the basin rims. Its development began in the Paleocene or Eocene and has continued until the present. As before stated, the basin is both a topographic and a structural basin. It exhibits from 900 m (3000 feet) to 1800 m (6000 feet) of relief between its lowest basin parts and the highest rim. The basin represents a superficial expression of the Tertiary structural basin and would still be filling with sediment except for the Green River, which has breached the north and south rims (Osmond 1964).

The basin contains a large number of geological formations, each having its own age and period of development. Seven of these formations furnish substrata for the 10 different communities analyzed in this study. These 7 formations (in sequence from the oldest to the youngest) are: Ankareh, Moenkopi, Mowry Shale, Parachute Creek and Evacuation Creek (members of the Green River formation), Uinta, Duchesne River, and glacial moraines.

METHODS

Ten study areas were established throughout the Uinta Basin (Fig. 1). The areas were chosen on the basis that *Eriogonum corymbosum* was present in the vegetational cover and by the geological formations upon which they occurred. Vegetational data and soil samples were collected during the summer

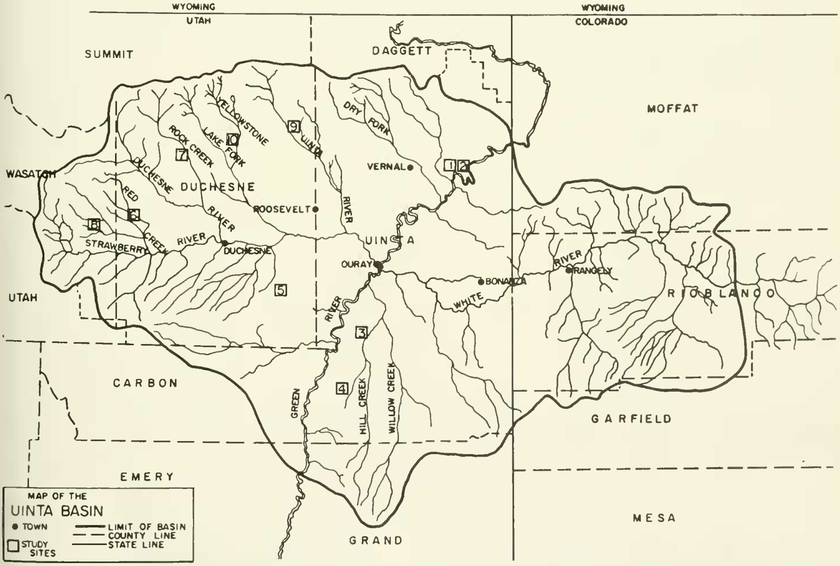

Fig. 1. Map of the Uinta Basin showing study site locations.

months (June through August) and analyzed in the laboratory during winter.

Vegetation data were gathered in midsummer (July 15 to August 10) when *E. corymbosum* and most other species had reached their maximum growth. Collecting of voucher specimens was done throughout the growing season. All specimens were deposited in the Brigham Young University herbarium.

The vegetational cover of each area was analyzed by employing the line-point method (Cain and Castro 1959). Ten 15-m (50-feet) transects were taken in each area, with the points distributed every 7 cm (3 inches) along the transect. This gave a total of 200 points per transect or 2000 points per area. Transects were located on a restricted random basis to eliminate bias and keep adjacent transects equal distances apart. At each point along the transect a seven-gage sharpened wire was lowered toward the ground and records were made of the first and all successive species hits. Where no vegetation occurred for the wire to touch, the hits were recorded as litter, rock, or bare ground.

Frequency and density data were acquired by use of a meter square quadrat placed at 3-m (10-foot) intervals along the 15-m transects. This gave a total of 50 quadrats per area. Frequency and density data were recorded only for shrubs, trees, and bunch grasses.

Percent surface cover for individual species and percent total vegetation cover were calculated as follows:

$$\text{\% surface cover for each species} = \frac{\text{Total hits for each species}}{\text{Total points}} \times 100$$

$$\text{\% total vegetational cover} = \frac{\text{Total hits for all species minus overlapping hits}}{\text{Total points}} \times 100$$

$$\text{\% composition of each species} = \frac{\text{Total hits for each species}}{\text{Total hits for all species}} \times 100$$

Percent frequency figures and density figures were obtained through use of the following relationships:

$$\text{\% frequency} = \frac{\text{Total quadrats a species appears in}}{\text{Total quadrats}} \times 100$$

$$\text{Density} = \#\ \text{plants}/50\ \text{quadrats} \times 83.00\ 50\ \text{quadrats}/\text{acre}^{[2]}$$

Differences and similarities between the different study sites were computed utilizing Sorensen's index of similarity (Sorensen 1948), as adapted by Dix and Butler (1960). The formula was as follows:

$$K = 2W/a + b \times 100.$$

K is the similarity index between two sites; a represents the sum of the coverage percentages of all species in one stand; b represents a similar figure for a second stand. W represents that part of the cover common to the species found in both stands. After the indices were obtained, an ordination matrix was constructed (Table 4). This placed the most similar sites next to each other and the more dissimilar sites at opposite ends of the matrix. The sites were then divided into four groups and a table (Table 6) was constructed from

TABLE 1. Site characteristics associated with 10 study areas.

Site	Soil depth (dm)	% Exposed bare ground	% Exposed rock	% Litter cover
Mowry	1.86	57.80	0.00	2.15
Moenkopi	4.36	76.50	2.00	0.10
Evacuation Creek	.98	59.00	9.40	4.10
Parachute Creek	1.77	56.50	6.25	2.75
Wells Draw	1.21	62.80	2.00	2.15
Red Creek	5.06	45.30	13.50	6.00
Rock Creek	3.32	13.80	7.80	6.60
Strawberry Valley	2.81	29.25	2.25	4.10
Uinta River	4.96	9.55	0.15	5.70
Yellowstone River	7.31	.90	0.00	4.25

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[2] This number (83.00 50 quadrats/acre) was obtained by dividing the number of square feet in 50 quadrats (i.e., 524.800 square feet/50 quadrats) into the number of square feet in an acre (i.e., 43,560 square feet/acre).

TABLE 2. Soil data for each study site by horizon. Each figure represents an average for three pits at each site.

Depth (in inches)	Sand %	Silt %	Clay %	pH 1:1	Soluble salts (ppm)	CEC in Meq./ /100 g.	Ca %	Mg %	K %	Na %
Mowry Formation										
Surf.	65	17	18	6.4	1099	36.88	53.4	28.3	9.7	8.1
0–6	63	18	18	4.8	1295	46.59	57.0	28.6	6.4	8.0
6–12	64	13	14	3.8	1127	48.61	61.8	23.4	5.7	9.0
12–18	63	13	15	3.7	1023	44.66	62.8	22.3	5.7	9.5
Moenkopi Formation										
Surf.	41	–	–	7.9	818	8.57	80.4	7.4	2.8	9.5
0–6	54	–	–	8.0	887	8.83	79.8	7.0	4.1	9.0
6–12	62	–	–	7.9	1214	9.29	72.1	9.2	6.1	9.9
12–24	65	–	–	7.9	1440	9.54	70.0	10.3	7.2	10.5
24–36	61	–	–	8.1	1875	8.84	68.2	13.0	7.5	10.8
Evacuation Creek Member										
Surf.	83	10	7	8.5	208	11.39	69.4	12.1	4.2	14.4
0–6	72	18	10	8.7	256	16.20	70.8	12.5	4.1	12.6
6–12	74	11	16	8.8	267	16.35	65.5	14.3	3.3	17.0
Parachute Creek Member										
Surf.	71	22	8	8.3	530	20.33	66.7	21.1	2.8	9.1
0–6	58	26	16	8.3	550	24.03	58.6	29.7	2.3	9.1
6–18	68	25	7	8.1	630	25.38	55.6	34.4	1.9	8.3
18–24	–	–	–	8.2	373	–	–	–	–	–
Wells Draw										
Surf.	78	18	3	8.4	196	13.27	76.9	7.9	6.9	8.2
0–6	69	23	8	8.5	234	16.75	76.1	10.5	5.5	9.8
6–12	62	23	10	8.2	401	23.71	70.9	12.5	3.3	13.4
12–24	80	16	4	8.5	229	17.94	78.1	9.9	1.6	10.4
Red Creek										
Surf.	42	37	24	8.8	386	14.88	48.4	41.2	5.1	5.4
0–6	32	46	22	9.0	410	16.75	38.1	50.9	4.3	6.8
6–12	27	47	26	9.2	461	16.62	31.8	54.5	5.2	8.5
12–24	32	43	26	9.5	519	14.75	30.3	50.5	3.7	15.5
24–36	44	38	18	9.6	630	14.08	28.1	49.8	4.3	17.8
Rock Creek										
Surf.	53	35	12	8.3	271	11.69	65.2	18.5	10.3	6.0
0–6	55	34	11	8.3	261	13.36	59.6	23.5	10.4	6.5
6–12	54	36	10	8.5	248	12.31	59.0	28.2	7.0	5.4
12–24	48	37	12	8.4	274	9.96	53.7	30.3	9.5	6.5
24–36	45	–	–	8.2	924	5.38	61.9	31.0	7.9	7.4
Strawberry Valley										
Surf.	51	29	20	8.2	305	8.83	62.7	20.4	10.0	6.9
0–6	50	30	20	8.3	357	8.63	58.5	26.9	6.9	7.9
6–12	43	38	19	8.5	279	10.63	55.6	32.9	4.3	7.1
12–24	51	34	15	8.7	211	6.35	55.3	34.3	4.3	6.1
Uinta River										
Surf.	59	28	13	7.3	308	15.88	56.3	24.1	12.7	6.9
0–6	58	27	14	7.8	391	19.36	56.6	22.3	13.7	7.4
6–12	58	25	17	8.0	400	19.45	54.8	23.8	14.3	7.1
12–24	60	23	17	8.1	394	18.07	51.9	27.1	13.9	7.0
24–36	60	22	18	8.2	410	17.43	49.6	29.4	13.9	6.7
Yellowstone River										
Surf.	80	16	5	5.9	42	8.54	66.3	15.6	9.1	9.1
0–6	83	12	4	6.7	47	5.83	66.0	18.4	6.8	9.0
6–12	89	7	4	6.7	46	4.45	62.9	21.1	7.6	8.8
12–24	85	10	4	6.8	35	4.77	63.6	22.0	5.0	9.5
24–36	87	8	4	6.8	36	4.42	60.9	23.6	6.1	9.4

these by averaging the cover percents for each species within the group. Those plant species showing the highest preference for group 1 were placed at the top of the table, and those species showing the least preference were placed at the bottom. From this table, 15 indicator species were selected and given adaptation numbers. Those species with the greatest preference for Group 1 were given the number one and those with the greatest preferences for Group 4 were assigned the number five.

By use of the selected indicator plants, Plot Index Values (PIV) for the 10 sites were obtained by applying the following formula (Dix and Butler 1960):

$$\text{PIV} = \frac{\text{Sum (relative composition of each indicator species} \times \text{its adaptation \#)}}{\text{Sum (relative composition of each indicator species)}}$$

From the Plot Index Values a linear ordination (Fig. 2) was constructed. Environmental correlations were then attempted with the use of this ordination.

A list was made of all plants noted in each area, and a composition study was made (Table 10) to indicate which families were the best represented in each area. All plant specimens collected during this study were deposited in the herbarium of the Brigham Young University.

Three soil pits were dug at each study area, and soil samples containing a composite sample of several hundred grams were taken from the surface, 0–15, 15–30, 30–60, 60–90 cm depths.

Soil depth was determined for each area by using pits and a 10-dm penetrometer (a sharpened ⅜" steel rod). The penetrometer was pushed into the ground at 10-foot intervals along the 50-foot transects used to collect the vegetational data.

Textural analysis of the soil was determined according to Bouyoucos (1936, 1951). Hydrogen ion concentration was determined for the same group of samples on a saturated paste, a 1:1 and a 1:5 ratio of soil to water. The 1:1 and 1:5 ratios were measured to indicate sodium content. A Beckmann glass electrode pH meter was used and the samples were prepared as outlined by Russell (1948).

Total soluble salts for the above-mentioned saturated pastes were determined by the use of a Wheatstone electrical conductivity bridge.

Cation exchange capacities for all collected soil samples were determined by using the standard ammonium acetate extraction method described by Russell (1948). Analysis for the amount of available calcium, magnesium, potassium, and sodium was found by using the ammonium acetate extraction from the cation exchange capacity determinations and a Beckmann model DU flame photometer.

RESULTS AND DISCUSSION

The 10 study sites were located throughout the Uinta Basin (Fig. 1). General physical and biological factors characteristic of these sites can be seen in Tables 1, 2, 3, and 8. Those sites located in the south and eastern parts of the basin showed shallow soils, little litter cover, and large exposed areas of bare ground. In contrast, those sites located in the western and northern parts of the basin exhibit deeper soils, increased amounts of litter cover, and much less exposed soil surface (Table 1).

Texturally the soils varied from sand to loams to sandy clay loams, with no distinct patterns being evident (Table 2). Soluble salt concentrations and cation exchange capacities generally increased from the north and

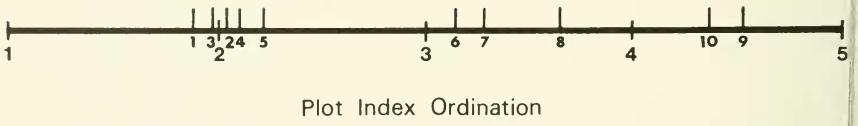

Fig. 2. The plot index values ordination. The linear arrangement of the 10 study sites according to their plot index values.

west parts of the basin toward the south and east parts. Hydrogen ion concentration (pH) varied from lows of 3.7 on the Mowry Shale formation to 9.6 in Red Creek on the Uinta formation, but again showed no distinct geographical patterns. Calcium and magnesium were the most abundant of the cations measured, with potassium and sodium seldom comprising over 10 to 20 percent of cation exchange capacity (Table 2).

Vegetationally the sites located in the north and west parts of the basin showed the highest shrub densities, even though grasses were the dominant life form type with regard to cover. Shrub cover, on the other hand, was the most important in the south and east parts of the basin (Table 3). Forb and annual plant cover showed no observable patterns. Total cover and diversity patterns (Table 3), in contrast to bare ground (Table 1), were highest near the mountains in the north and west basin areas. Numbers of species per study site varied from 11 to 29, with an average of 22. The prevalent species (the 24 most prominent species found to occur across the study area) are listed in Table 8. It can be seen they represent a rather typical assemblage of the cold temperate desert shrub areas of the intermountain region.

TABLE 5. Study site groups as determined from the similar index matrix.

Group	Study site
1	Mowry study site Parachute Creek member of the Green River Formation study site
2	Evacuation Creek member of the Green River Formation study site Moenkopi study site
3	Red Creek study site Rock Creek study site
4	Strawberry Valley study site Uinta River study site Yellowstone River study site

TABLE 3. Vegetation characteristics associated with the 10 study sites.

Site	Total cover	Percent cover Shrub	Forb	Grass	Annual	Shrub density (plants/Acre)	Diversity*
Mowry	40.1	78.0	17.0	4.0	1.0	7300	.17
Moenkopi	20.5	81.0	15.0	3.0	1.0	2515	.24
Evacuation Creek	27.5	77.0	4.0	7.0	12.0	8449	.41
Parachute Creek	34.5	64.0	1.0	32.0	3.0	4542	.34
Wells Draw	33.5	68.0	1.0	20.0	11.0	7138	.40
Red Creek	34.8	68.0	0.5	30.0	2.0	15572	.53
Rock Creek	72.6	28.0	3.0	65.0	4.0	15660	.44
Strawberry Valley	64.4	39.0	13.0	45.0	3.0	24652	.82
Uintah River	84.6	37.0	9.0	51.0	4.0	37716	.69
Yellowstone River	94.9	22.0	4.0	60.0	14.0	7301	.53

*Diversity = $1/\Sigma\, pi^2$

TABLE 4. Similarity index matrix for the 10 study sites: Mowry = 1; Moenkopi = 2; Evacuation Creek = 3; Parachute Creek = 4; Wells Draw = 5; Red Creek = 6; Rock Creek = 7; Strawberry = 8; Uinta = 9; Yellowstone = 10.

	1	4	3	2	5	6	7	8	9	10
1	—	48.0	45.6	45.0	40.6	32.1	20.8	17.1	17.5	11.7
4			57.6	50.5	46.0	35.2	25.3	21.2	17.3	14.7
3				62.4	45.7	35.5	22.5	18.9	17.8	12.9
2					50.2	39.1	23.1	17.6	15.7	11.6
5						31.7	29.8	25.6	18.3	13.2
6							50.6	21.6	16.2	17.5
7								24.2	27.8	29.3
8									25.5	33.5
9										62.2
10										—

Ordination Analysis

Analysis of the vegetation of the different areas and of the areas themselves was attempted by evaluating the differences and similarities between sites. To accomplish this, the areas were ordered by application of an index of similarity (Table 4).

The matrix was designed to place those sites with the greatest similarities closest together and those with the greatest differences farthest apart. Therefore, the Moenkopi and the Evacuation Creek sites are interpreted to be the most similar and will thus exhibit similar community characteristics, and the Moenkopi and the Yellowstone sites are the most dissimilar and should exhibit few factors in common. The position of each area within the matrix was determined by placing the highest index values along the diagonal of the square and the lowest index values toward the upper right-hand corner of the table. The magnitude of the indices decreases from left to right when comparing the Mowry study site with the Yellowstone River study site or the other sites listed to the right of the Mowry. Similarly, the indices increase from top to bottom or from right to left when the other areas are compared to the Yellowstone River study site.

TABLE 6. Average percent composition values in the four groups for all species with a percent composition greater than 0.50 percent.

	Plant species	Groups			
		1	2	3	4
*1	Atriplex confertifolia	5.68	4.37		
1	Chenopodiuum leptophyllum	4.98	2.90	0.43	0.07
1	Gila leptomeria	3.42	1.10		1.66
2	Ephedra torreyana		3.07		
	Astragalus saurinus		2.20		
	Juniperus utahensis	2.01		2.68	
	Stanleya pinnata		1.73		
2	Eriogonum corymbosum	61.05	48.78	34.40	8.51
2	Tetradymia spinosa		4.96		
	Mentzelia dispersa	0.25	0.68		
3	Amelanchier utahensis		1.28	1.10	0.25
	Poa secunda	1.28		0.38	1.40
	Chrysothamnus parryi		0.37		0.86
3	Oryzopsis hymenoides	3.91	7.01	4.94	7.98
3	Agropyron trachycaulum		0.24	33.10	0.16
4	Chrysothamnus viscidiflorus	0.27	1.50	1.03	5.70
	Artemisia nova		9.60		
	Lepidium montanum		1.31		
	Solidago petradoria		0.87		
	Poa palustris				1.25
	Tetradymia glabrata				1.36
	Astragalus tenellus				3.1
4	Cercocarpus montanus			14.16	
	Sitanion hystrix	0.12	0.18	0.16	0.36
4	Artemisia tridentata	1.78		6.35	8.31
	Purshia tridentata				0.2
	Astragalus convallarius				1.0
	Sphaeralcea coccinea			0.48	1.4
	Lappula redowskii		0.97	0.46	0.31
	Chrysothamnus nauseosus				1.34
	Opuntia polyacantha			0.08	1.34
	Lepidium densiflorum				1.0
5	Xanthocephalum sarothrae				4.2
5	Agropyron smithii				20.64
5	Stipa comata	018		6.65	26.1

*These numbers are adaptation numbers and were assigned to different indicator species. The indicator species were chosen on the basis of their indicated preference for a certain group or groups as shown in the above table.

To help understand the association of individual species to these relationships, the areas listed on Table 4 were divided into the four groups shown in Table 5.

The percent composition figures of all species with percents greater than 0.50 percent were then averaged in each group. A list (Table 6) was then prepared placing those species with the greatest preference for Group 1 at the top and those species with the greatest preference for Group 4 at the bottom of the list. You can now determine some characteristic distribution or associational patterns for many of the individual species.

Although Table 4 served effectively to segregate the different study areas, it did not show the degree of compositional differences or similarities actually existent between them. Because such information was desirable, Plot Index Values (PIV) (Table 7) described by Dix and Butler (1960) were employed to assign a spatial position to each study site on a linear ordination and thus to actually measure to some degree the ecological distance between the different areas of study. To accomplish this, 15 indicator species were chosen from the list in Table 6 and assigned adaptation numbers from 1 to 5. Those species with the greatest preference for Group 1 were assigned the adaptation number 1, and those with the least preference for Group 1 were assigned adaptation number 5. Under such a system, an area will have a PIV of 1 when it contains only indicator species assigned adaptation numbers of 1. Likewise, an area will have a PIV of 5 when it contains only indicator species as-

TABLE 7. Plot index values (PIV) for 10 study sites.

	Study Site	PIV
1	Mowry	1.86
4	Parachute Creek	2.08
3	Evacuation Creek	1.95
2	Moenkopi	2.03
5	Wells Draw	2.21
6	Red Creek	3.14
7	Rock Creek	3.28
8	Strawberry Valley	3.65
9	Uinta River	4.51
10	Yellowstone River	4.37

TABLE 8. Prevalent species list for 10 study sites along with average percent cover in the different areas sampled.

		Study site									
Species	Importance value	1*	3	2	4	5	6	7	8	10	9
Eriogonum corymbosum	1421.5	30.8	13.2	13.6	17.7	13.9	11.5	11.9	9.1	13.3	7.4
Stipa comata	563.1	.2				.4		12.5	1.5	50.9	28.6
Oryzopsis hymenoides	389.5	.3	.7	.4	2.7	6.4	1.2	6.9	18.8	1.2	2.4
Agropyron smithii	380.8								14.7	38.0	23.3
Artemisia tridentata	285.9				1.3	.2	3.5	4.4	3.2	14.3	13.9
Agropyron trachycaulum	202.8			.2			10.4	39.5			.6
Xanthocephalum sarothrae	113.3								.9		13.3
Bromus tectorum	106.0	.4				.1		2.6		9.4	.5
Gilia leptomeria	55.8	2.8				1.3			.7	6.5	
Sphaeralcea coccinea	42.7							.9		.4	4.9
Atriplex confertifolia	39.3		2.1	.9	4.3	.6					
Chenopodium leptophyllum	37.0	3.2	2.4		.9	.2	.2	.5	.2		
Chrysothamnus viscidiflorus	33.2		1.3		.2	.2	.6	.7	14.0		1.2
Cercocarpos montanus	32.7						9.6	6.8			
Astragalus tenellus	25.7								8.6		
Amelanchier utahensis	23.1			.8			.6	.9		.2	.9
Lepidium densiflorum	22.7									4.1	3.5
Agrophron spicatum	21.8		1.2	4.1	8.9				.8		
Chrysothamnus nauseosus	21.6									2.3	2.9
Chenopodium fremontii	21.6									3.6	
Artemisia nova	21.1					10.9					
Lappula redowskii	19.8					1.1	.1	.7		1.5	
Sitanion hystrix	18.8	.1	.1			.2		.3		1.7	
Poa sandbergii	18.8	1.1						.7	1.1		3.5
Opuntia polyacantha	18.0						.6	.2		3.0	2.9

*Numbers equivalent to study sites as listed in Table 7.

signed adaptation numbers of 5. Areas which contain a mixture of species having different adaptation numbers will have PIV's intermediate between 1 and 5.

The ordination (Fig. 2) was prepared by placing the computed PIV's so that each area exhibited a linear relationship to all the others.

This ordination (Fig. 2) separates the 10 study sites into two fairly distinct groups. These two groups correlate well with the distributional patterns of the two varieties of *Eriogonum corymbosum* discussed earlier. Variety *corymbosum* occurs in the group to the left, which contains the Mowry Shale study site, the Moenkopi formation study site, the Evacuation Creek and Parachute Creek members of the Green River formation study sites, and the Wells Draw study site. Variety *erectum* occurs in the group to the right, which contains the Rock Creek study site, the Uinta River study site, the Yellowstone River study site, the Strawberry Valley study site, and the Red Creek study site. By consulting Table 4 and Figure 2, we see that those study sites in the eastern and southern part of the basin are much more alike and become less so as you travel west and northward across the basin. Similarly, those study sites in the north and western part of the basin exhibit high indexes of similarity, but as you travel south and eastward across the basin, the sites become less and less alike. Those sites in the eastern and southern parts of the basin occupy areas which belong to the deserts of the Uinta Basin and are below 5500 feet elevation. Those sites in the north and western part of the basin are all above 6000 feet and are either in or very near the Uinta Mountains. This factor would tend to place these sites in areas of higher rainfall, and thus in the nondesert areas of the basin.

The response of the prevalent plant species to the ordination is shown in Table 8. Since the patterns of these species along the ordination do not, in themselves, suggest reasons for or factors involved in their distributional patterns, other ecological data collected during this study were also plotted against the above-described ordination (Figs. 3, 4, 5). This was to determine if any correlation between these factors and distributional patterns might be discovered.

Total cover and soil depth show positive correlation to the ordination; bare ground, cation exchange capacity, and soluble salts are negatively correlated to the ordination and thus may so influence the distributional patterns of those species which showed some correlation with the ordination. The species are *Eriogonum corymbosum, Chenopodium leptophyllum, Ariplex confertifolia, Agropyron smithii, Artemisia tridentata, Stipa comata, Tetradymia spinosa, Agropyron trachycaulum, Agropyron spicatum, Cercocarpus montanus*, and *Xanthocephalum sarothrae.* As is evident from studying Table 8, the above species show definite patterns of distribution along the ordination and these patterns appear restricted to certain areas of the ordination. These species, then, can to some extent be classed as indicators of the areas to which they appear restricted.

The species *E. corymbosum, C. leptophyllum*, and *A. confertifolia* show decreasing composition percents from left to right (Table 8), but the composition of *A. smithii, A. tridentata*, and *S. comata* increase from left to right (Table 8). Looking at Figures 3 and 4, we see that shrub cover, bare ground, cation exchange capacity, and total soluble salts decrease from left to right, but total cover, grass cover, diversity, and soil depth increase. This would indicate generally that *E. corymbosum, C. leptophyllum*, and *A. confertifolia* are best adapted to areas having low diversity, shallow soil, elevated levels of exchangable ions and soluble salts, and little total ground cover. *A. smithii, A. tridentata*, and *S. comata*, on the other hand, grow best in areas of high diversity where the soils are moderately deep and low in exchangeable ions and soluble salts and exhibit high degrees of total ground cover.

It is evident that there exist definite relationships between these ecological factors and the distributional patterns of the listed species. From Table 2 and Figures 3, 4, and 5, we see that where total soluble salts and cation exchange capacities are at their peaks and soil depth and total cover are at their lower levels, the plants *E. corymbosum, C. leptophyllum*, and *A. confertifolia* reach their greatest importance in the community. In the case of *A. confertifolia*, it occurs only in sites which have appreciable amounts of soluble

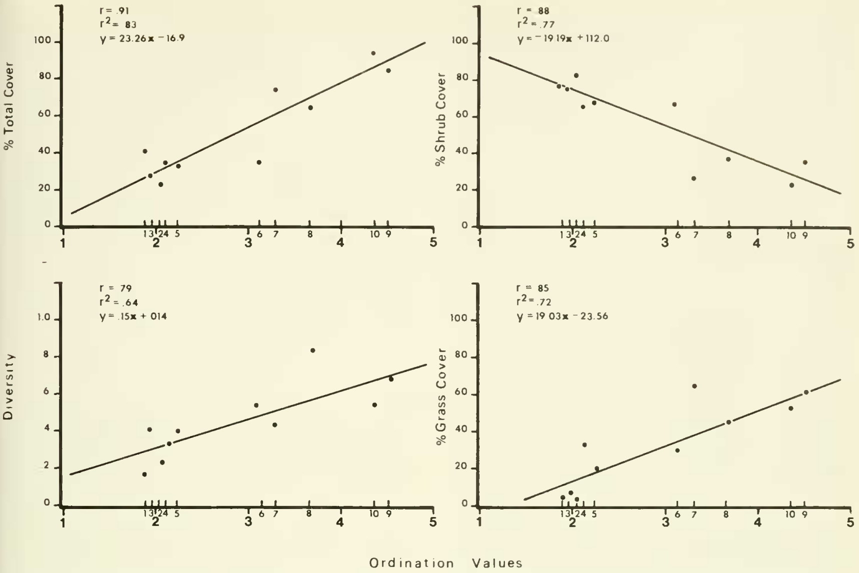

Fig. 3. The relationships of community characteristics (i.e., total cover, diversity, shrub cover, and grass cover) to the ordination. Correlation data are shown.

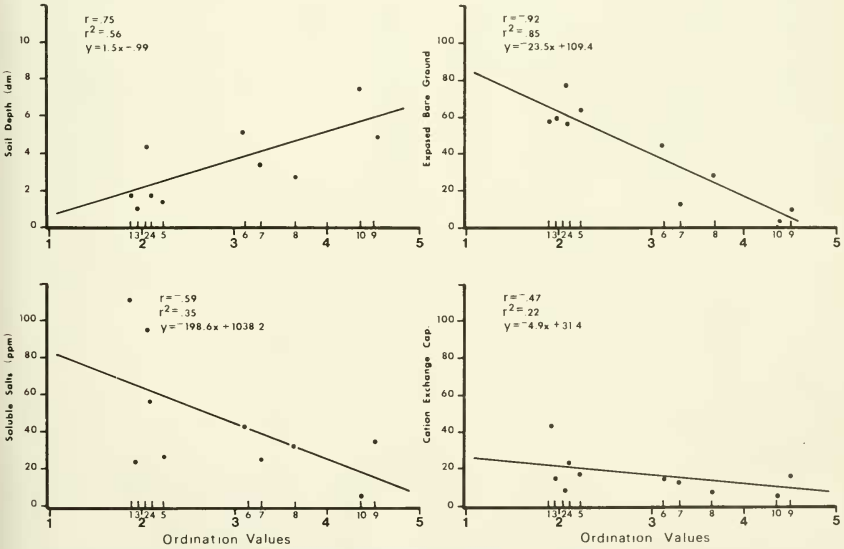

Fig. 4. The relationships of site characteristics (i.e., soil depth, soluble salts, exposed bare ground, and cation exchange capacity) to the ordination. Correlation data are shown.

salts in the soil. Upon examination of the patterns shown by *A. tridentata, A. smithii,* and *S. comata,* we see that they reach their greatest importance where the reverse of the above conditions are true. Indications are that these last three species are able to withstand the competition of other plants more readily than the previous three species.

On further examination of Table 8, another interesting relationship is made apparent. The three species of *Agropyron, A. smithii, A. spicatum,* and *A. trachycaulum* show definite areas of preference or distribution. In each case, the distribution patterns are discrete and show little or no overlap.

Of the other factors examined (i.e., percent sand, silt, clay, pH, and calcium, magnesium, potassium, and sodium), none appeared to have any relationship to the distributional patterns of the species studied. But in some cases, a few of the factors did show distinct relationships to other related soil factors. As the percent sand in the soil decreases, the percent of silt increases. The percent clay appears to show some relationship to the above two factors in that it tends to act somewhat like the silt in relationship to the sand. Calcium and magnesium also show direct correlation (Table 2). As the concentrations of calcium decrease or increase, there is a corresponding increase or decrease in the concentrations of magnesium. The concentrations of potassium and sodium also appeared to be related (Table 2) in that where the levels of sodium are high, the levels of potassium are low and vice versa.

Family Composition

A total of 173 species of vascular plants, representing a total of 93 genera and 40 families, were collected from the above described study areas. Of these species, 72.7 percent belonged to the families shown in Table 9.

The figures indicate that these nine families contribute about 70 percent of the species to the cold temperate desert shrub re-

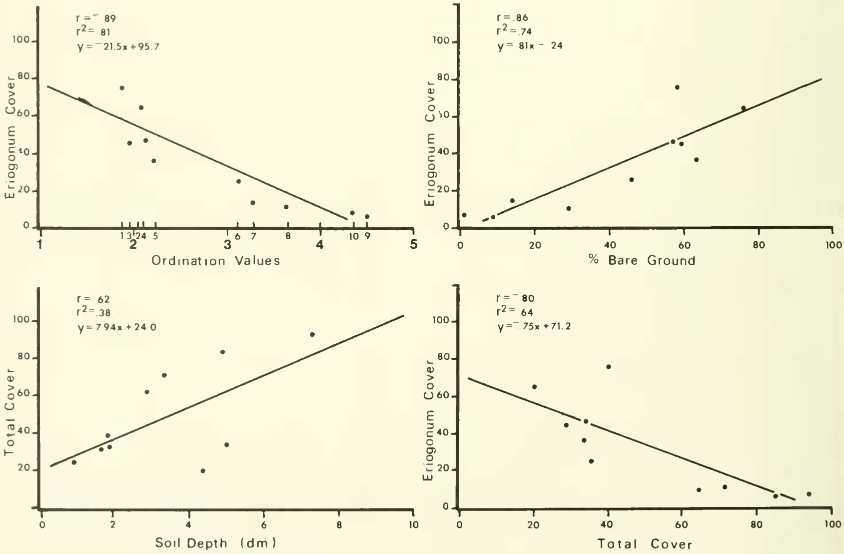

Fig. 5. The relations of *Eriogonum* cover to the ordination and to other site characteristics. Correlation data are shown.

gions of the Uinta Basin, regardless of topography, soil depth, soil texture, soil pH, or other factors measured in this study. A similar family composition chart (Table 10) has been computed on an individual study site basis.

As can be seen, the nine plant families, with the exceptions of Polygonaceae and Chenopodiaceae, and then these only in two of the study areas, show a fair similarity to the earlier figures. The ecological or phytogeographical significance of the dominance of these nine families is not known, but further investigation along such lines tends to hold interest.

Discussion

There appears in this study evidence that the distributional patterns of some species native to the Uinta Basin are related to measurable characteristics of their communities. *Eriogonum corymbosum*, *Chenopodium leptophyllum*, *Atriplex confertifolia*, *Stipa comata*, *Artemisia tridentata*, and *Agropyron smithii* are affected by both vegetational and edaphic factors of the community. Being aware that organisms can and do modify the physical environment (Goiger 1957, McIntosh 1957, Polunin 1960), it is still apparent that factors which restrict one species in one community may very well allow other species to reach their greatest importance in another environment.

The vegetation of the different areas studied showed remarkable similarity at the family level and extreme variability at the species level. There was a definite increase in total vegetative cover, grass cover, and diversity as you moved from southeast to northwest across the Uinta Basin. As the vegetative cover increased, the soil depth also generally increased.

Paralleling these trends, the importance of such plants as *Eriogonum corymbosum*, *Chenopodium leptophyllum*, and *Atriplex confertifolia* in the community decreased, while such plants as *Stipa comata*, *Agropyron smithii*, and *Artemisia tridentata* became more important. Other species (i.e., *Gilia leptomeria*, *Oryzopsis hymenoides*, *Chrysothamnus viscidiflorus*, and *Amelanchier utahensis*) did not seem to be affected by such trends. The species (Table 8) *Tetradymia spinose*, *Agropyron trachycaulum*, *Cercocarpus montanus*, *Agropyron spicatum*, and

TABLE 9. Dominant plant family composition of 10 study sites.

Family	Percent
Asteraceae	22.0
Poaceae	9.3
Brassicaceae	8.7
Fabaceae	5.8
Chenopodiaceae	5.8
Scrophulariaceae	5.7
Boraginaceae	5.7
Polygonaceae	5.7
Polemoniaceae	4.0
Total	72.7

TABLE 10. Comparisons of the total number of plant families, total number of plant species and the percentage of species contributed to the flora by nine major plant families.

Study Site	Total number families	Total number species	Percent of species in nine plant families								
			1*	2	3	4	5	6	7	8	9
Mowry	11	29	17	10	—	—	28	3	—	10	3
Parachute Creek	8	19	37	16	5	—	5	—	5	16	16
Evacuation Creek	12	26	27	12	4	—	19	—	4	8	4
Moenkopi	19	39	18	13	8	5	8	—	8	8	3
Wells Draw	18	51	26	12	8	2	12	2	4	6	6
Red Creek	15	37	27	8	8	8	8	8	3	8	—
Rock Creek	14	35	23	17	3	6	3	6	3	3	3
Strawberry Valley	15	45	24	13	2	11	4	13	2	7	4
Uinta River	16	43	26	12	5	9	5	7	7	5	5
Yellowstone River	16	43	23	12	5	—	2	2	7	14	5

*1 = Asteraceae; 2 = Poaceae; 3 = Brassicaceae; 4 = Fabaceae; 5 = Chenopodiaceae; 6 = Scrophulariaceae; 7 = Boraginaceae; 8 = Polygonaceae; 9 = Polemoniaceae.

Xanthocephalum sarothrae showed definite correlation to certain study sites, but the basis for such correlation was not determined.

Of the edaphic factors measured, soil depth, soluble salts, and cation exchange capacity showed positive relationships to the distribution patterns of the above-mentioned species. The distributional patterns of *Artemisia tridentata* and *Atriplex confertifolia* were found to be in agreement with Kearney et al. (1914), Fautin (1946), Thatcher (1959), and Robertson et al. (1966). *A. tridentata* occurred near the mountains on soils moderately deep to deep exhibiting fairly low levels of soluble salts. *A. confertifolia* was found only where the soils showed fairly high levels of soluble salts and where the soils were generally shallow. Paralleling *A. tridentata* are the distributional patterns of *Agropyron smithii* and *Stipa comata*. The distribution patterns of *Chenopodium leptophyllum* and *Eriogonum corymbosum* show some relationship to that of *A. confertifolia*.

Factors of the soil, such as pH, concentrations of the cations calcium, magnesium, potassium, and sodium, and soil texture did not appear to influence the distributional patterns of species associated with this study.

Eriogonum corymbosum var. *corymbosum* showed correlation with the above-mentioned factors as well as with total cover. As is evident from the data, *E. corymbosum* var. *corymbosum* prefers areas of low diversity, high shrub cover, shallow soils, high soluble salts, high cation exchange capacities, and low total ground cover. *Eriogonum corymbosum* var. *erectum*, on the other hand, reaches its highest development in communities of high diversity, high grass cover, and deep soils which are low in soluble salts and cation exchange capacities. That both are found on a number of different geological formations supports the hypothesis that this species is an indicator of peculiar soil types.

Other factors involved in the distribution of the above species are competition and community disturbance and erosion. It is suggested that competition between species is probably important because field work indicates, for example, that as the total cover of a community increases, the importance of *E. corymbosum* decreases. Although no measurements were made on community disturbance and erosion, 8 of the 10 study sites showed varying degrees of disturbance and erosion. The 2 sites which did not show erosion but only slight disturbance, indicated by the presence of such plants as *Bromus tectorum* and *Xanthocephalum sarothrae*, also exhibited the lowest composition percents for species such as *E. corymbosum*.

It is suggested that *E. corymbosum* var. *corymbosum*, which is found only in study sites located in the desert areas of the basin, is a shallow soil variety and one that prefers communities that show high degrees of disturbance, little competition, and fairly high levels of soluble salts in the soil and are found at elevations below 5500 feet. *Eriogonym corymbosum* var. *erectum*, on the other hand, appears to compete best in communities above 6000 feet that show less disturbance than the desert areas and have deeper soils and low levels of soluble salts.

Although the suggested associations between the site characteristics measured in this study and the vegetation do not prove causal relationships, they do serve to aid in the assignment of probable causes of the observed vegetational patterns. To gain a complete and final insight into the ecology of *Eriogonum corymbosum* and its associated species of the cold temperate desert shrub regions of the Uinta Basin, further and more intense investigations of those factors studied in this paper, as well as further investigation of other important community characteristics, will be necessary.

LITERATURE CITED

BILLINGS, W. D. 1949. The shadscale vegetation zone of Nevada and eastern California in relation to climate and soils. Amer. Midl. Nat. 42:87–102.

_____. 1950. Vegetation and plant growth as affected by chemically altered rocks in the western Great Basin. Ecology 31:62–74.

_____. 1951. Vegetational zonation in the Great Basin of western North America, pp. 101–122. *In* Les Bases Ecologiques de la Vegeudration de la Vegetation de Zones Arides. U. I. S. B. Paris.

_____. 1952. The environmental complex in relation to plant growth and distribution. Quart. Rev. Biol. 27:251–265.

BOUYOUCOS, G. J. 1936. Directions for making mechanical analysis of soils by the Hydrometer Method. Soil Sci. 42:225–230.

———. 1951. A recalibration of the Hydrometer Method for making mechanical analysis of soils. Agron. Jour. 43:434–438.

Cain, S. A., and G. M. de Oliveira Castro. 1959. Manual of vegetational analysis. Harper and Brothers, Pubs., New York.

Cannon, H. L. 1952. The effect of uranium-vanadium deposits on the vegetation of the Colorado Plateau. Amer. Jour. Sci. 250:735–770.

Dastrup, B. C. 1963. Vegetational changes of the Uinta Basin since settlement. Unpublished master's thesis. Brigham Young University, Provo, Utah.

Dix, R. L., and J. E. Butler. 1960. A phytosociological study of a small prairie in Wisconsin. Ecology 41:316–327.

Flowers, S. 1960. Ecological studies of the flora and fauna of Flaming Gorge Reservoir Basin, Utah and Wyoming. Anthropological Papers No. 48, Department of Anthropology, University of Utah.

Fautin, R. W. 1946. Biotic communities of the Northern Desert Shrub. ecol. Mono. 16:251–310.

ates, D. H., L. A. Stoddart, and C. W. Cook. 1956. Soil as a factor influencing plant distribution on the Salt-Deserts of Utah. Ecol. Mono., 26:155–175.

eiger, R. 1957. The climate near the ground. Howard University Press, Cambridge, Massachusetts.

raham, E. 1937. Botanical studies in the Uinta Basin of Utah and Colorado. Ann. Carnegie Mus., Pittsburgh 26:1–432.

———. 1903. Contributions to western botany. Contr. West. Bot. 11:14.

earney, T. H., et al. 1914. Indicator significance of vegetation in Tooele Valley, Utah. J. Agr. Res. 7:365–417.

rucheberg, A. R. 1951. Intra-specific variability in the response of certain native plants to serpentine soil. Amer. J. Bot. 38:408–418.

———. 1954. The ecology of serpentine soils 111. Plant species in relation to serpentine soils. Ecology 35:267–274.

arsell, R. E. 1964. Geomorphology of the Uinta Basin—a brief sketch. Guidebook to the geology and mineral resources of the Uinta Basin, Publisher Press, Salt Lake City, Utah.

McConkie, D. L. 1941. An economic survey of the Uinta Basin. Unpublished master's thesis. Brigham Young University, Provo, Utah.

McIntosh, R. P. 1957. The York Woods, a case history of forest succession in southwestern Wisconsin. Ecology 38:29–37.

Osmond, J. C. 1964. Tectonic history of the Uinta Basin, Utah. Guidebook to the geology and mineral resources of the Uinta Basin, Utah. Publisher Press, Salt Lake City, Utah.

Peterson, P. P. 1952. Geology of the Thistle area, Utah. Unpublished thesis. Brigham Young University, Provo, Utah.

Polunin, N. 1960. Introduction to plant geography and some related sciences. McGraw-Hill Book Company, Inc., New York.

Reveal, J. L. 1967. Notes on *Eriogonum* V: A revision of the *Eriogonum corymbosum* complex. Great Basin Nat. 27:183–229.

Robertson, D. R., et al. 1966. Vegetation and soils of alkali sagebrush and adjacent big sagebrush ranges in North Park, Colorado. J. Range Manage. 19:17–20.

Russell, D. A. 1948. A laboratory manual for soil fertility students, 3d ed. Wm. Brown Company, Dubuque, Iowa.

Shantz, H. L., and R. L. Piemeisel. 1940. Types of vegetation in Escalante Valley, Utah, as indicators of soil conditions. U.S. Dept. Agric. Tech. Bull. 713.

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content. Konge, Dan. Vidensk. Selsk. JS:4:1–34.

Thatcher, A. P. 1959. Distribution of sagebrush as related to site differences in Albany County, Wyoming. J. Range Manage. 12:55–61.

Walker, R. B. 1954. The ecology of serpentine soils II. Factors affecting plant growth on serpentine soils. Ecology 35:259–266.

Welsh, S. L. 1957. An ecological survey of the vegetation of the Dinosaur National Monument, Utah. Unpublished thesis. Brigham Young University, Provo, Utah.

Whittaker, R. H. 1954. The ecology of serpentine soils IV. The vegetation response to serpentine soils. Ecology 35:275–288.